

1. The first step is to identify the problem. This involves understanding the current situation and what needs to be changed.

Mobile agents, operating within the above mentioned mobile agent technology, make a contact to other agents in the moved-to place, i.e. a mobile agent or a resident agent, and may be served as appropriate. A place is a location
5 provided by a server existing on the network to which the agent is moved and which supports a contact among agents. Preferably, the server accommodates the differences between the hardware and between the platforms.

10 The mobile agent technology enables a mobile agent to act as a proxy of a human being in handling work such as, for example, dynamically adjusting a schedule of internal meetings in compliance with the schedule of attendees and the status of reservations of conference rooms, and also acquiring desired information distributed on the network.

15 In the prior art mobile agents, however, it can be difficult to realize a flexible, smooth information exchange and coordination among agents because the communications among agents are realized by a conventional method call (subroutine call) or by low level message
20 passing. Further, it is often a requirement to define the processing of a stereotypical conversation in order to communicate by using an agent. This requirement can result in a load to a user of an agent. Furthermore, it can be difficult to communicate between different types of agents
25 because no agent communication language is used to realize the communications among a variety of agents.

It can be appreciated that a "conversation" between human beings generally consists of steps in which:

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1. A speaker prepares a content to be spoken in order to convey the speaker's intent to a listener;
 2. The speaker then begins to speak;

3. The listener listens to the speech and understands the flow of the conversation;

4. The listener associates the speech with the background of the speech from what the listener has experienced;

5. The listener understands the content of the speech; and

6. The listener takes an action as a result.

If a messaging system of a computer is defined as one which simulates the message processing of a natural language and is designed for recycling by patterning a conversation in this way, a message which is closer to a natural language than in prior art message processing systems can be processed. As a result, an intelligent message system can be constructed which is more user friendly and allows a series of packets having a certain context to be exchanges with the flow of contexts being followed.

OBJECTS AND ADVANTAGES OF THE INVENTION:

It is a first object and advantage of this invention to provide a communication system which is capable of having a conversation with an agent communication language which is intuitively and easily understandable to a human being, and also having an agent (mobile or resident agent) to communicate.

It is another object and advantage of this invention to provide a communication system which enables a conversation among agents (mobile or resident agents) to proceed concurrently and asynchronously.

It is a further object and advantage of this invention to provide a communication system in which agents can

communicate to each other without knowledge of a variety of agent communication languages and communication protocols.

It is still another object of this invention to provide a communication system which realizes high speed parallel
5 conversation processing.

It is still a further object of this invention to reduce the work and the time required for developing and maintaining a program as much as possible in providing a support to communication among agents.

10 It is a further object of this invention to provide a message processing system which is capable of flexibly dealing with conversations among agents.

It is another object of this invention to provide a message processing system which results in less load to a
15 communication network.

Further objects and advantages of this invention will become more apparent from a consideration of the drawings and ensuing description.

SUMMARY OF THE INVENTION

20 The foregoing and other problems are overcome and the objects of the invention are realized by methods and apparatus in accordance with embodiments of this invention, wherein a communication system is provided which is capable of having a conversation with an agent communication
25 language that is intuitively and easily understandable to a human being.

This invention provides an agent with a software part

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(agent communication system) which performs operations that represent the functions of a human ear and a mouth. In such an agent communication system, the functions of the ear are provided in the form of an API (Application Program Interface) "handleMessage", while the functions of the mouth are provided in the form of an API "sendMessage". In the preferred embodiment of this invention, these API's are implemented as an object oriented programming language method of an agent communication language manager object for an agent communication system.

In generating a conversation, an agent prepares an agent communication language (ACL) which represents a human conversation and sends it by passing it to the sendMessage method. A message packet contains a sender field and a destination field by which the agent communication system can recognize the location of a conversation partner.

On the other hand, in the node which receives the message packet, the data (message packet) from the network is received by a protocol manager which is a component that processes a data coming through the network and which passes it to the handleMessage method of the agent communication language manager object. The handleMessage method understands the message packet and executes the content.

According to one aspect of this invention, the agent communication system, upon transmission or receipt of a message packet, determines whether or not a new conversation is initiated and generate a new conversation thread when it is determined that a new conversation is initiated. The conversation thread enables conversations to proceed concurrently and asynchronously among a

plurality of agents (mobile or resident agents).

According to another aspect of this invention, the functions of the ear and the mouth are provided to an agent simply by instantiating the agent communication language manager object.

According to one aspect of this invention, a message processing method is provided for execution by a message processor which is connected to a network and has a conversation thread control part that is capable of generating a plurality of conversation threads, the method includes the steps of: detecting a message packet containing a destination information and a conversation thread identifying information; determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exists in the message processor; generating a new conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor; and sending the message packet to a destination which corresponds to said destination information.

According to another aspect of this invention, a message processing method is provided for execution by a message processor which is connected to a network and has a conversation thread control part that is capable of generating a plurality of conversation threads, the method includes the steps of: detecting a message packet containing a destination information, a conversation thread identifying information and a content information; determining whether or not a conversation thread corresponding to the conversation thread identifying

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control to the corresponding conversation thread when it is determined that the corresponding conversation thread exists in the message processor.

According to a still further aspect of this invention, a message processing method is provided for execution by a message processor which is connected to a network and has a conversation thread control part that is capable of generating a plurality of conversation threads, the method includes the steps of: detecting a message packet containing a destination information and a conversation thread identifying information; determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exists in the message processor; and generating a new conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor.

According to a further aspect of this invention, a message processing method is provided for execution by a message processor which is connected to a network and has a conversation thread control part that is capable of generating a plurality of conversation threads, the method includes the steps of: detecting a message packet containing a conversation thread identifying information and a content information; determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exist in the message processor, passing a control to the corresponding conversation thread when it is determined that the corresponding conversation thread exists in the message processor; and analyzing the content of the content information.

According to a further aspect of this invention, a message processing method is provided for execution by a message processor which has a plurality of conversation threads and a conversation part object including a conversation thread control part that is capable of controlling the plurality of conversation threads, the message processor being capable of sending a message to another message processor through a network, the method includes the steps of: halting the plurality of conversation threads; sending the conversation part object to another place through the network; and resuming the plurality of conversation threads at the another message processor.

According to a still further aspect of this invention, a message processor is provided which is connected to a network, the processor including: a plurality of conversation threads; an agent communication language manager for detecting a message packet which contains a destination information, a conversation thread identifying information and a content information; a first conversation thread control part for determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exists in the message processor; a second conversation thread control part for generating a new conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor; and a protocol manager for converting the message packet to a protocol which corresponds to a network to which the message processor is connected.

According to a still further aspect of this invention, a message processor is provided which is connected to a network, the processor includes: an agent communication

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language manager for detecting a message packet which contains a conversation thread identifying information; a first conversation thread control part for determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in said message packet exists in said message processor, and a second conversation thread control part for generating a new conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor.

According to a still further aspect of this invention, a message processor is provided which is connected to a network and has a conversation thread control part which is capable of generating a plurality of conversation threads, the processor includes: an agent communication language manager for detecting a message packet which contains a conversation thread identifying information and a content information; a first conversation thread control part for determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exists in the message processor; and a second conversation thread control part for passing a control to said corresponding conversation when it is determined that said corresponding conversation thread exists in said message processor.

According to a still further aspect of this invention, a message processor is provided which is connected to a network and has a conversation thread control part which is capable of generating a plurality of conversation threads, the processor includes: a protocol manager for receiving a message packet containing a conversation thread identifying information; a first conversation thread

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control part for determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exists in the message processor; and a second conversation thread control
5 part for generating a new conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor.

According to a still further aspect of this invention, a message processor is provided which is connected to a
10 network and has a conversation thread control part which is capable of generating a plurality of conversation threads, the processor includes: a protocol manager for receiving a message packet containing a conversation thread identifying information and a content information; a first
15 interpreter for determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exists in the message processor, and a second interpreter for passing a control to the corresponding conversation thread when it is
20 determined that the corresponding conversation thread exists in the message processor.

According to one of the aspects of this invention, a recording media is provided which stores therein a message processing program for execution by a message processor
25 which is connected to a network and has a conversation thread control part capable of generating a plurality of conversation threads, the message processing program including: a program code which instructs the message processor to detect a message packet containing a
30 destination information and a conversation thread identifying information; a program code which instructs the message processor to determine whether or not a

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conversation thread corresponding to the conversation thread identifying information contained in the message packet exists in the message processor; a program code which instructs the message processor to generate a new
5 conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor; and a program code which instructs the message processor to send the message packet to a destination which corresponds to the destination
10 information.

According to a further aspect of this invention, a media is provided which stores therein a message processing program for execution by a message processor which has a conversation thread control part capable of generating a
15 plurality of conversation threads and is connected to a network, the message processing program including: a program code which instructs the message processor to detect a message packet containing a destination information, a conversation thread identifying information
20 and a content information; a program code which instructs the message processor to determine whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exist in the message processor; a program code which
25 instructs the message processor to generate a new conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor; a program code which instructs the message processor to convert the message packet to a
30 protocol which corresponds to which the message processor is connected; and a program code which instructs the message processor to send the message packet to the destination which corresponds to the destination

information.

According to a further aspect of this invention, a media is provided which stores therein a message processing program for execution by a message processor which has a conversation thread control part capable of generating a plurality of conversation threads and is connected to a network, the message processing program including: a program code which instructs the message processor to detect a message packet containing a conversation thread identifying information; a program code which instructs the message processor to determine whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exist in the message processor; and a program code which instructs the message processor to generate a new conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor.

According to a further aspect of this invention, a media
is provided which stores therein a message processing
program for execution by a message processor which has a
conversation thread control part capable of generating a
plurality of conversation threads and is connected to a
network, the message processing program including: a
program code which instructs the message processor to
detect a message packet containing a conversation thread
identifying information and a content information; a
program code which instructs the message processor to
determine whether or not a conversation thread
corresponding to a conversation thread identifying
information contained in the message packet exists in the
message processor; and a program code which instructs the

message processor to pass a control to the corresponding conversation thread when it is determined that the corresponding conversation thread exists in the message processor.

5 According to a further aspect of this invention, a media
is provided which stores therein a message processing
program for execution by a message processor which has a
conversation thread control part capable of generating a
plurality of conversation threads and is connected to a
10 network, the message processing program including: a
program code which instructs the message processor to
detect a message packet containing conversation thread
identifying information; a program code which instructs the
message processor to determine whether or not a
15 conversation thread corresponding to a conversation thread
identifying information contained in the message packet
exists in the message processor; and a program code which
instructs the message processor to generate a new
conversation thread when it is determined that the
20 corresponding conversation thread does not exist in the
message processor.

According to a further aspect of this invention, a media is provided which stores therein a message processing program for execution by a message processor which has a conversation thread control part capable of generating a plurality of conversation threads and is connected to a network, the message processing program including: a program code which instructs the message processor to detect a message packet containing conversation thread identifying information and content information; a program code which instructs the message processor to determine whether or not a conversation thread corresponding to the

conversation thread identifying information contained in the message packet exists in the message processor; a program code which instructs the message processor to pass a control to the corresponding conversation thread when it is determined that the corresponding conversation thread exists in the message processor; and a program code which instructs the message processor analyze the content of the content information.

According to a further aspect of this invention, a media
is provided which stores therein a message processing
program for execution by a message processor which has a
conversation thread control part capable of generating a
plurality of conversation threads and is capable of sending
a message to another message processor through a network,
the message processing program including: a program code
which instructs the message processor to halt the plurality
of conversation threads; a program code which instructs the
message processor to send the conversation part object to
another place through the network; and a program code which
instructs the message processor to resume the plurality of
conversation threads.

According to a still further aspect of this invention, a media is provided which stores therein a plurality of objects to be loaded to a message processor which has a conversation thread control part capable of generating a plurality of conversation threads and is connected to a network, the message processing program including: a plurality of conversation threads; an agent communication language manager for detecting a message packet which contains a destination information, conversation thread identifying information and content information; a first conversation thread control part for determining whether or

not a conversation thread corresponding to the conversation thread identifying information contained in said message packet exists in the message processor; and a second conversation thread control part for generating a new conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor; and a protocol manager for converting the message packet to a protocol which corresponds to a network to which the message processor is connected.

10 According to a still further aspect of this invention, a media is provided which stores therein a plurality of objects to be loaded to a message processor which has a conversation thread control part capable of generating a plurality of conversation threads and is connected to a network, the message processing program including: an agent communication language manager for detecting a message packet which contains conversation thread identifying information; a first conversation thread control part for determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exists in the message processor; and a second conversation thread control part for generating a new conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor.

According to a still further aspect of this invention, a media is provided which stores therein a plurality of objects to be loaded to a message processor which has a conversation thread control part capable of generating a plurality of conversation threads and is connected to a network, the message processing program including: an agent communication language manager for detecting a message

packet which contains conversation thread identifying information and content information; a first conversation thread control part for determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exists in the message processor; and a second conversation thread control part for passing a control to the corresponding conversation when it is determined that the corresponding conversation thread exists in the message processor.

According to a still further aspect of this invention, a media is provides which stores therein a plurality of objects to be loaded to a message processor which has a conversation thread control part capable of generating a plurality of conversation threads and is connected to a network, the message processing program including: a protocol manager for receiving a message packet containing a conversation thread identifying information; a first conversation thread control part for determining whether or not a conversation thread corresponding to the conversation thread identifying information contained in the message packet exists in the message processor; and a second conversation thread control part for generating a new conversation thread when it is determined that the corresponding conversation thread does not exist in the message processor.

BRIEF DESCRIPTION OF THE DRAWINGS

The above set forth and other features of the invention are made more apparent in the ensuing Detailed Description of the Invention when read in conjunction with the attached Drawings, wherein:

- Fig. 1 shows a distributed network environment in which a mobile agent of this invention operates;
- Fig. 2 is a block diagram showing one embodiment of a hardware configuration of a client system or a server system of this invention;
- Fig. 3 is a block diagram of one embodiment of processing components in the client site or the server site of this invention;
- Fig. 4 schematically shows an example of a message packet of this invention;
- Fig. 5 is a block diagram of one embodiment of processing components in the client (or server) site of this invention;
- Fig. 6 is an object interaction diagram among the components in a preferred embodiment of this invention;
- Fig. 7 schematically shows a conversation content monitoring part control table in a preferred embodiment of this invention;
- Fig. 8 is a block diagram of one embodiment of processing components in the server (or client) site of this invention;
- Fig. 9 is an object interaction diagram among the components in a preferred embodiment of this invention;

- Fig. 10 schematically shows an interpreter control table in a preferred embodiment of this invention;
- Fig. 11 schematically shows a translator control table in a preferred embodiment of this invention;
- 5 Fig. 12 is a block diagram of one embodiment of processing components in the client (or server) site of this invention;
- Fig. 13 is a block diagram of one embodiment of processing components in the server (or client) site of this invention;
- 10 Fig. 14 is a flow chart showing an embodiment of processing steps taken when an agent communication system of this invention is moved over the network; and
- 15 Fig. 15 is an object interaction diagram among the components in a preferred embodiment of this invention.

Identically labeled elements appearing in different ones of the above described figures refer to the same elements but may not be referenced in the description for all figures.

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DETAILED DESCRIPTION OF THE INVENTION

The embodiment of this invention will now be described with reference to the drawings. With reference to Fig. 1, a distributed network environment 150 is shown which executes mobile objects of this invention. Each server 112-115 is provided with a place 102-105 for serving mobile agents

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125, 135, 141, 151 and 161. The group of places in the distributed network environment 150 is referred to as a crowd.

5 An application 113 for forming and moving a mobile agent, for example mobile agent 111, is defined in a client system 101. Mobile agents, such as mobile agent 125, are sent out by the application 113 and may contact other agents (mobile or resident agents) existing in each place 102-105, send a request, and receive a result of a request. An agent which
10 contacts a mobile agent to provide a service is hereinafter referred to as an actor agent. A place provides a support to the contact between agents. Mobile agents, such as mobile agent 125, may hold a result of a request received from an actor agent, continue to move, or send the result
15 to the client 101 or another place during movement.

The mobile agent 125 (or a resident agent) may send a message packet to another place and execute a conversation and an instruction in the another place.

20 Fig. 2 schematically shows a hardware configuration of each node (a server or a client site) existing on the distributed network environment 150 shown in Fig. 1. Each node 100 has a main central processing unit (CPU) 1 and a main memory 4. The main CPU 1 and the main memory 4 are connected to hard disk drives 13 and 30, which act as
25 auxiliary storage devices, via a bus 2. Storage media drives including a floppy disk drive (FDD) 20, the hard disk drives (HDD) 13 and 30, CD-ROM drives 26 and 29, and a MO drive 28, are connected to the bus 2 through controllers including, for example, a floppy disk
30 controller (FDC) 19, an IDE controller 25 and a small computer system interface (SCSI) controller 27.

A portable storage media such as a floppy disk is inserted in to the storage media drive such as the floppy disk drive 20. The floppy disk or other storage media of the hard disk drive 13 and a ROM 14 have recorded therein a computer program which provides instructions to the CPU 1 in cooperation with an operating system (OS) to practice this invention. During operation, the program is loaded into the memory 4 for execution. The computer software may be compressed or divided into multiple pieces for storage in multiple media.

The node system 100 may be a system which has a user interface hardwired, such as a pointing device (e.g., a mouse 7 or a joy stick, etc.) or a keyboard 6 for input and a display (e.g., a CRT 12) for presenting visual data to a user. A parallel port 16 may be provided for connecting an external output device such as a printer. The node system 100 may have a modem connected thereto via a serial port 15 for connection to the network through the serial port 15 and the modem or through a token ring or a communication adapter 18 to communicate with other computer systems.

It can be appreciated that this invention may be implemented in a conventional personal computer (PC), a workstation, a general purpose computer or a combination of them. It should be noted, however, that these components are chosen as exemplary components and that not all components are necessarily an indispensable component of the invention.

For example, it is not necessary to install a user interface in the server side because it is sufficient to have a basic data processing function such as a CPU and a memory, and a communication function. It is also

5 sufficient for the client side to have a configuration that
is needed to send out a message packet (described later),
including a communication function and an input means for
designating a message packet and instructions to send out
the message packet. Further, when a machine is controlled
remotely from a portable terminal, it would be enough to
have a data processing function and a communication
function to receive an instruction to send the message
packet from the portable terminal, detect it and send out
10 the message packet.

The operating system (OS) in the client side and the server
side may be implemented as one which supports on a standard
basis, a GUI multi-windows environment such as WindowsNT
(trademark of Microsoft), Windows95 (trademark of
15 Microsoft), Windows3.x (trademark of Microsoft), OS/2
(trademark of IBM), X-Window system (trademark of MIT) on
AIX (trademark of IBM), and Solariz (trademark of Sun Micro
Systems). The OS may also be implemented to support a
character based environment such as PC-DOS (trademark of
20 IBM) and MS-DOS (trademark of Microsoft), or a real time OS
such as OS/Open (trademark of IBM) and VxWorks (trademark
of Wind River Systems, Inc.) without being limited to any
specific operating system environment.

With reference to the block diagram in Fig. 3, a system
25 configuration of the server side in the preferred
embodiment of this invention is described.

An agent 201 is either a mobile agent which was sent to
this server or a resident agent which is resident in this
server. The agent 201 may have a dialog with the agent
30 communication system 200 by sending out or receiving a
message packet which will be described later. An agent

communication language manager 203 is a component for receiving a message sent from the agent 201 or the existing system and network, and for transmitting messages to these systems.

- 5 A conversation thread control part 205 is a component for controlling a conversation thread 207 that corresponds to each conversation with an agent, for example agent 201, for forming a suitable thread in conformance to the flow of conversation, or for giving the control to the thread which
- 10 has been generated. Multiple conversations are split into multi-threads to accept multiple conversations asynchronously. The thread is referred to as a conversation thread. According to one aspect of this invention, a plurality of such conversation threads are
- 15 generated by which conversations are held in parallel and asynchronously with a plurality of agents.

- A message log 211 is a component for memorizing conversations. A conversation content monitoring part 217 is a component which conducts a policy check as to whether
- 20 or not a conversation is valid from a conversation log stored in the message log and the content of the current message. A conversation content monitoring part loader 215 is a component for calling the conversation monitoring part 217 which corresponds to the message type of the message
- 25 packet 300.

- A translator 221 is a component for translating the agent communication language used in the conversation into another language. A translator loader 219 is a component for controlling a group of translators.
- 30 An interpreter 225 is a component for understanding and

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executing the content of a conversation. A plurality of different such interpreters are provided corresponding to ontologies and describing languages which will be described later. The interpreters each have a format check routine, a content interpretation routine and an execution routine, each of which is specific to an ontology. Take, for example, an ontology of traffic reservation. Assuming that a content "R, flight, Narita to Tacoma, 1997/07/06/15:00-1997/07/06/1800" is received. This content is checked in accordance with a predetermined format, and a specific content interpretation routine is executed. The interpretation routine interprets that "R" is a command which instructs the routine to make a reservation by accessing a database in a given airline to execute an execution routine for checking the reservation status. A reservation is made for a non-smoking seat, economy, FlightXX26 for Tacoma, Seattle, departing Narita airport at 15:00 on July 6, 1997 and the reservation is confirmed to the sender.

An interpreter loader 223 is a component for controlling a group of interpreters 225. A protocol manager 230 is a component for converting to a protocol which conforms to the type of network to be connected.

Each of functional blocks in Fig. 3 has been described. These functional blocks (components), which are logical functional blocks, are not meant to be implemented as an independent integral hardware or software and may be implemented as a complex of hardware devices and software routines, or common hardware devices and software routines. Further, not all of the functional blocks in Fig. 3 are necessarily a component which is indispensable to this invention.

For example, it would be enough to install interpretation execution parts such as the conversation content monitoring part 217, the translator 221 and the interpreter 225 because this invention provides an agent with a special function to have a conversation with other agents or an existing system. Components such as the conversation content monitoring part loader 215, the translator loader 219, and the interpreter loader 223 may optionally be included or excluded within a given configuration. In one aspect of this invention, because one or more specific number of conversation threads are provided to converse with a specific agent, thread control part 205, message log 211 and ID generator 213 are not an indispensable components.

Fig. 4 schematically illustrates a message packet 300 as used in a preferred embodiment of this invention. Fig. 5 shows an operational condition of each component in Fig. 3 when a message is generated.

In a message type 301 contained in the message packet 300 in Fig. 4, a performative of the agent communication language (ACL) is used in the preferred embodiment of this invention. The ACL is a high level language which provides for communication among agents in a form that is similar to human language, and includes, for example, one provided by FIPA (Foundation for Intelligent Physical Agents), KQML (Knowledge Query Manipulation Language), and KIF (Knowledge Interchange Format). These ACLs are discussed in "SEMANTICS FOR AN AGENT COMMUNICATION LANGUAGE" by Yannis Labrou, A Doctoral Dissertation for the PhD Defense Examination, submitted to the PhD Defense Committee at the Computer Science and Electrical Engineering Department (CSEE) of the University of Maryland Graduate School, and

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"TR CS-97-03, A Proposal for a new KQML Specification, by Yannis Labrou and Tim Finin, February 3, 1997".

Included in the performative of KQML which is one of the ACLs are;

5 ask-if, ask-all, stream-all, eos, tell, untell, deny,
insert, uninsert, delete-one, delete-all, undelete,
achieve, unachieve, advertise, unadvertise, subscribe,
error, sorry, standby, ready, next, rest, discard,
10 register, unregister, forward, broadcast, transport-
address, broker-one, broker-all, recommend-one, recommend-
all, recruit-one, recruit all.

Referring again to Fig. 4, a sender 303 is a sender of a
message, while a receiver 305 is a receiver of a message.
A response ID 307 is an ID which follows a preceding
15 conversation. When an agent has a conversation with a
plurality of parties, a plurality of response ID's are
allocated corresponding to the conversation threads. This
will be described in further details below.

A conversation ID 309 is an ID which tells the conversation
20 partner to respond with this ID. The describing language
type 311 is information which specifies the language
describing a content. The ontology 313 is information
which specifies the ontology that the content specifies.
In the preferred embodiment of this invention, a ticket
25 purchase ontology, a numerical calculation ontology and a
yellow page ontology, etc., are provided.

The content 315 is the particular subjects or topics
covered in a message and contains, in the preferred
embodiment of this invention, a software routine for

FOI b7D b7C b7E b7F b7G b7H b7I b7J b7K b7L b7M b7N b7O b7P b7Q b7R b7S b7T b7U b7V b7W b7X b7Y b7Z

forming instructions after it has moved to another place. The content 315 may also internally contain a message packet for movement to another place via a relaying paint. If the content 315 does contain a message packet for movement, then a "From" entry and a "To" entry are provided to indicate a true sender and a final receiver, respectively.

An operational condition of each component in Fig. 3 during message generation will now be described with reference to Fig. 5. The agent 201 sends a message packet 300 (shown in Fig. 4) to the agent communication system 200. In the preferred embodiment of this invention, the components shown in Fig. 3 are defined as a class of an object oriented programming language. Each object, upon generating a message, prompts other objects to operate by sending an instruction to such other objects. These prompts between components is shown in the object instruction diagram of Fig. 6.

The agent communication language manager 203, upon receiving the message packet 300, determines that the message packet 300 is one for generating a conversation depending on whether it is called by a "sendMessage" or a "handleMessage" method and instructs the conversation thread control part 205 to process. The conversation thread control part 205 determines whether or not to instruct an already generated conversation thread 207 to process with reference to the response ID 307 which is contained in the message packet 300. If the conversation thread control part 205 determines that it is a new conversation, it generates a new conversation thread 207, instructs the generator 213 via the new conversation thread 207 to allocate a new conversation ID 309 to the new

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conversation thread 207, and moves control to the new conversation thread 207.

In this invention, because the conversation threads are dynamically generated in this way, conversations can be held in parallel and asynchronously with other system (agents or existing system). In the preferred embodiment of this invention, the response ID 307 is allocated with an ID that is uniquely identified on the network such as, for example, "URL + Date + Time+ Serial Number".

10 If a conversation thread 207 corresponding to the response ID 307 has existed, the conversation thread control part 205 determines that this is not a new conversation and moves control to the corresponding and existing conversation thread 207. If it is desired to continue
15 conversation, the conversation thread 207 instructs the ID generator 213 to allocate a conversation ID 309.

The message log 211 memorizes the message packet 300 which is sent to the conversation thread 207. The conversation content monitoring part loader 215 calls a conversation
20 content monitoring part 217 corresponding to the message type 301 of the message packet 300. The conversation content monitoring part 217 corresponding to the message type 301 may be called by providing a conversation content monitoring part table 330 as shown in Fig. 7, or by using
25 a class name of the conversation content monitoring part 217 which is the same as the message type 301.

The conversation content monitoring part 217 conducts a policy check as to whether or not a conversation is valid based on the conversation log stored in the message log 211
30 and the content of the current message. For example, if

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the message type 301 of the received message packet 300 is a value "sorry" (a message type which means that the content of the conversation is understandable but that the receiving part does not have a capability to process), a reference is made to the message log 211 for a message type 301 of the message which has a corresponding response ID 307 and an immediately preceding ID. It is then determined that the message type 301 is of no problem if it is of a type which can be valid as a conversation, for example "ask-if" a message type which queries about the processing capability of the other party. If it is determined that the message type 301 is in error, for example, if it is determined to be of a message type 301 can not be valid (e.g., the conversation "sorry"), then the message type 301 is found to be in error (not valid) and an action is taken such as sending a message packet of "error" (a message type 301 which means an error) to the sender 303 of the message packet 300.

If it is determined that a conversation can be valid, a message packet 300 is sent from the conversation thread 207 to a node which is designated as a receiver 303 through the protocol manager 230. The protocol manager 230 converts the protocol to one which conforms to the type of the network to be connected so that the agent communication system 200 can send and receive a message packet 300 without being aware of the network protocol.

Now with reference to Fig. 8 and Fig. 9, operational conditions of each component at the node which received the message packet so sent is described.

The agent communication language manager 203 which has received a message packet 300 from the protocol manager 230

determines that the received message packet 300 is one for receiving a message as it is called with the "handleMessage" method and asks the conversation thread control part 205 to handle it. In the preferred embodiment of this invention, the protocol manager 230 knows the existence of the agent communication language manager 203 as the latter internally instantiates, it can send the incoming data to the agent communication language manager 203.

- 10 The conversation thread control part 205 determines whether or not to ask the conversation thread 207 to process the message packet 300 with reference to the response ID 307 contained in the message packet 300. if the conversation thread control part 205 determines that the packet 300 is
- 15 a new conversation, it generates a new conversation thread 207 and transfers the packet 300 to the conversation thread 207 for processing.

- When a conversation thread 207 corresponding to the response ID 307 has existed, the conversation thread control part 205 determines that the packet is not a new conversation and transfers it to the corresponding, existing conversation thread 207 for processing. The message log 211 memorizes a message packet 300 which is sent to the conversation thread 207.
- 20

- 25 The conversation content monitoring part loader 215 calls a conversation content monitoring part 217 which conforms to the message type 301 of the message packet 300. The conversation content monitoring part 217 conducts a policy check as to whether or not a conversation is valid based upon the conversation log stored in the message log 211 and the content 315 of the current message. If it is
- 30

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determined that a conversation is valid, the conversation thread 207 transfers control to the interpreter loader 223 for processing. The interpreter loader 223 understands the agent communication language of the message packet 300 and determines whether or not the describing language type 311 contained in the message packet 300 and an interpreter 225 which corresponds to the ontology 313 are stored in an interpreter control table 350 shown in Fig. 10.

If the interpreter 225, which corresponds to the agent communication language, describing language type 311 and the ontology 313 of the received message packet 300 is stored in the interpreter control table 350, the content 315 is interpreted by that interpreter 225. If an interpreter 225 which corresponds to the agent communication language, describing language type 311 and the ontology 313 of the received message packet 300 is not stored in the interpreter control table 350, a determination is made as to whether or not an interpreter 225 which corresponds to that combination exists in the interpreter library which is managed (accessible) by the system.

If the interpreter 225 exists, it is registered in the interpreter control table 350 and the content 315 is interpreted by using that interpreter 225. If an interpreter 225 which corresponds to a combination of the agent communication language, describing language type 311 and the ontology 313 does not exist in the interpreter library, determination is made as to whether or not an interpreter 225 which corresponds to a combination of the describing language type 311 and the ontology 313 exists in the interpreter library. If it does not exist, it is determined that the message can not be processed. In the

preferred embodiment of this invention, the onotologies are hierarchically structured so that an interpreter 225 of a best matching ontology is used.

5 If the interpreter 225 exists, the control is transferred to the translator loader 219 to translate the content 315 into the agent communication language of the discovered interpreter 225. The translator loader 219 makes a reference to the translator control table 340 and determines whether or not there exists a translator which
10 can execute the requested translation. In the preferred embodiment of this invention, if the translator does not exist, the translator library is searched in the way as the interpreter library was searched, an entry is made to the table 340 and the translated content 315 is processed by
15 the selected interpreter 225. If the translator 225 does not exist, it is determined that the message can not be processed.

In the preferred embodiment of this invention, the result of the interpretation by the interpreter 225 is transmitted
20 to the agent 231 where it is processed according to the content of instructions which are described in the content 315. Depending on what is in the content 315, either the conversation thread 207 is destroyed, a process is entered to begin a new message generation, or a new agent is
25 generated. In the preferred embodiment of this invention, the interpreter 225 returns the control to the conversation thread 207. The conversation thread 207 will standby until another message is received.

30 In contrast to many API calls in a prior art procedural system, a conversation is asynchronous so that it is unpredictable when the receiving party replies in response

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to a conversation sent from a sending party to the receiving party. It is possible that information which is possessed by the receiving party could be returned at a timing which is changed by an external force (such as an action by other agents). The reply is sent as a message packet in such case too. The conversation thread 207 waits with a "wait0" method until a reply following the conversation is returned. The "wait0" method renders the conversation thread 207 in wait state and waits until it is woken up by a function (method) like "notify0" or others. When the reply is returned, the message is given to the agent system 200. If it is found that the message is a message following the existing conversation, the thread of sleeping conversation is woken up and given the message.

In the preferred embodiment of this invention, when the agent 231 started a conversation in the past and is waiting for a reply, that conversation was started through the agent communication system 200 (sending the "sendMessage" method to the agent communication system) and an object "Conversation" is returned as a return value of the "sendMessage" method. The object "Conversation" is associated with an object called "Result" which holds a state. In the preferred embodiment of this invention, the agent 231 can receive a notification by examining the state which is held by the object "Result" through a polling.

In the preferred embodiment of this invention, in order to provide the agent 201 with the agent communication system 200 which is a conversation part of this invention, a coding in JDK (Java Development Kit: Trademark of Sun Microsystems) is used.

The agent communication 200 of this invention can be

provided to the agent 201 simply by instantiating an ACLManager by;

```
aclManager = new aclManager(agentName, protocolName, port);
```

To start a conversation, a "kqml" object is prepared for
5 example, and the conversation is started simply by;

```
Conversation Thread conv =  
    (ConversationThread) aclManager.sendMessage(kqml);
```

When waiting for a reply, a polling is conducted by;

```
Result res = conversation.getResult 0;  
10     if (res.isAvailable0) {do something appropriate}
```

The reply returned or a content of the message sent by another agent is correctly interpreted and executed by an interpreter of the default agent communication system 200.

In the preferred embodiment of this invention described
15 above, the interpretation execution parts are registered in the control tables at the time of execution. However, the interpretation execution parts need not be registered at the time of execution and, instead, a check may be made as to what interpretation execution parts exist to form and
20 maintain an interpretation execution part control table.

While the message packet 300 moves among nodes in the preferred embodiment of this invention, the message packet 300 may be sent in an attachment to a mobile agent 233 (as shown in Figs. 12 and 13). In such a case, the mobile
25 agent 233 moves around places and holds conversations with the message packet 300 attached thereto. It is further

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possible to carry out complex jobs such as having a conversation at another place using the process result. The movement of the mobile agent over the network is accomplished, for example, by executing the steps shown in
5 Fig. 14.

Fig. 15 is an object interaction diagram which illustrates an exemplary interaction among the components of one preferred embodiment of this invention.

As described above, this invention provides a communication
10 system which is capable of conversing with an agent communication language which is intuitively understandable to a human being in communication among agents (mobile or resident agents).

In one of the aspects of this invention, a message
15 processing system is provided which enables a high speed processing by reducing unnecessary decision logics.

In another aspect of this invention, a communication system is provided in which agents can communicate with each other without being conscious of a variety of agent communication
20 languages and communication protocols.

In still another aspect of this invention, a communication system is provided which realizes a high speed parallel conversation processing.

In a further aspect of this invention, the work and the
25 time required for developing and maintaining a program are reduced as much as possible in providing a support to communication among agents.

For Office Use

In still a further aspect of this invention, a message processing system is provided which is capable of flexibly dealing with conversation among agents.

5 In another aspect of this invention, a message processing system is provided which gives less load to a communication network.

In still another aspect of this invention, a message processing system is provided in which resources required for execution are decreased.

10 Although described in the context of preferred embodiments, it should be realized that a number of modifications to these teachings may occur to one skilled in the art. While the invention has been particularly shown and described with respect to preferred embodiments thereof, it will be
15 understood by those skilled in the art that changes in form and details may be made therein without departing from the scope and spirit of the invention.

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